FORAGE PRODUCTION FOLLOWING PRICKLY PEAR CONTROL WITH THREE DIFFERENT HERBICIDES IN WEST TEXAS

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STEWART GREGORY HOHENSEE

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by

STEWART GREGORY HOHENSEE

APPROVED:

Dr. Cody B. Scott

Mr. Corey Owens

Dr. Morgan Treadwell

Dr. Greg Krukonis

May 2020

APPROVED:

Dr. Micheal W. Salisbury

Dean, College of Graduate Studies and Research

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ABSTRACT

The cost of spraying prickly pear can vary greatly between herbicide applications. Choosing which herbicide to use is important to consider when comparing to returning forage production. This study took place on two different locations in West Texas. Three different chemicals were sprayed on prickly pear to evaluate mortality rate, canopy cover reduction, and forage production. The chemicals in this study include Tordon 22K, Surmount, and Mezavue. Herbicides were applied at their recommend IPT rate on prickly pear. All three herbicides improved prickly pear mortality but results differed by location. Canopy cover and forage production were similar following treatment applications. Preliminary results suggest that Tordon 22K may be the most cost effective application for prickly pear control.

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INTRODUCTION

Prickly pear (*Opuntia* sp.) occurs on about 28% of rangelands (10.3 million ha) in Texas (Petersen et al. 1988). The plant is a perennial invasive succulent that can be expensive to control. In dense stands of prickly pear, forage production is reduced along with livestock movement. Several methods have been assessed to reduce and eliminate prickly pear such as mechanical, biological, and chemical. Using herbicides, either alone or in combination with other methods is often considered the most efficient method of prickly pear management (Ferrell et al. 2014).

When not suppressed, prickly pear can replace native vegetation and reduce forage availability for livestock and wildlife. Prickly pear reproduces both through seed dispersal and vegetative regeneration (Ferrell et al. 2014). Once fruit is mature, both livestock and wildlife consume the fruit or tunas dispersing viable seeds (Felker and Russell 1988). In addition, prickly pear pads broken off from the plant will root down creating a new plant.

This project assessed the efficacy of control and the cost effectiveness of three different herbicides approved for control of prickly pear on rangelands. These include Tordon 22k, Surmount, and MezaVue. Tordon 22k was the first of the chemicals in production. The active ingredient is Picloram at 24.4% of the total content. Surmount then followed in production and added another main ingredient. The two main ingredients for Surmount are Picloram at 13.24% and Fluroxypyr at 10.64% of total content. The last chemical made available was MezaVue. Its main ingredients are Aminopyralid at 5.15%, Picloram at 10.06%, and Fluroxypyr at 12.53%.

Rangeland Ecology and Management

MezaVue is the newest of the three chemicals available to the public for purchase. MezaVue’s selling point is that it can completely kill prickly pear in half the time of Surmount and a third of the time of Tordon 22K. Each of the three chemicals have a significantly different price point. Tordon is listed at $20.87 per liter, Surmount at $15.69 per liter and MezaVue at $31.70 per liter. Because of differences in broadcast application rates, Tordon 22K is typically the most cost effective to apply, followed by MezaVue and Surmount. Although Surmount is less costly per liter, the recommended rate of application is double that of Tordon 22K or MezaVue for aerial, ground broadcast, and foliar individual plant treatment (IPT) applications. IPT applications recommend a 1% v/v rate for MezaVue and Tordon 22K, and 2% v/v for Surmount. These different price points lead to the discussion of whether spraying is more cost effective using more expensive herbicides to control prickly pear at a faster rate, which would allow for quicker herbaceous forage recovery.

OBJECTIVES

1. Assessed the efficacy of three different herbicides to control prickly pear.

2. Determined the most cost-effective herbicide application for control of prickly pear.

LITERATURE REVIEW

The predominant type of prickly pear that inhabits Texas is Texas prickly pear (*Opuntia engelmannii* Salm-Dyck ex Engelm.) (Wicks et al. 1969). This species can be found in west central Texas and readily suppresses herbaceous forage production for livestock and wildlife (Price et al. 1985). Weather, soil type, and overgrazing are the primary factors that influence prickly pear abundance (Petersen et al. 1988). This succulent is very drought tolerant, has high water use efficiency, and flourishes when rangelands are overgrazed (Felker and Russell 1988). Detached prickly pear pads can survive dry weather spells up to 1 or 2 years because of their ability to re-root back into the soil (Wicks et al. 1969).

The morphology of prickly pear has adapted to create a crassulacean acid metabolism (CAM). This allows prickly pear to open its stomata only at night, which reduces water loss (Mayeux and Johnson 1989). Prickly pear fruit (tunas) and cladodes (pear pads) provide some nutritional forage when selected by livestock and wildlife (McMillan et al. 2002). The pads do not hold much nutritional value compared to the fruit, but both are often consumed when herbaceous forage is depleted.

Prickly pear reproduces through seed dispersal from the tunas and the pads broken off and scattered by animals and mechanical machinery (Felker and Russell 1988). Dense stands of prickly pear often form from essentially one single pad that takes root and branches out from produced pads that take root themselves. Some stands of cactus can be populated together and form one congested stand that reaches 30 feet in width (Ferrell et al. 2014).

Once an ecosystem becomes invaded with prickly pear, control options are typically limited and expensive. Control options include four methods: chemical, mechanical, fire, and biological (Ferrell et al. 2014). Of these, biological and mechanical are often least effective because pads quickly root down when broken off of the plant, creating a new plant. In addition, ingestion of pads by livestock can cause health issues. Spines can impact an animal’s oral cavity by causing infections and reduced intake (Petersen et al. 1988). Consumption of tunas can cause ulceration and bacterial infection in the oral cavity as well as the gastrointestinal tract (Hernandez et al. 2003). Ingestion of tunas has also led to rumen compaction from the seeds contained in the tunas.

Mechanical methods include root plowing, chaining with dozers, and grubbing. Most of these methods provide only temporary control of prickly pear and in some to most cases, it increases the densities of prickly pear (Ferrell et al. 2014). Mechanical control is considered the least effective method.

Fire, when used on its own, can be effective in controlling invasive species, but prickly pear often resprouts after topkill with fire. Fire, when used in combination with herbicides, has shown to be a very effective method (Blair et al. 1993). Prescribed burning damages the cuticle of prickly pear pads, improving absorption of herbicides. Unfortunately, prescribed burning is often not an option because dense stands of prickly pear suppress grass production, thereby reducing fuel loads for fire.

When prescribed burning is not an option, herbicides alone are the most effective at controlling an invasive species. Individual plant treatment (IPT) and broadcast application are two approaches of chemical application. Recommended rates of most herbicides are at least 1% of herbicide to the total tank mixture. The rates for the herbicide used in this trial are Tordon 22K at 1.17 - 2.34 liters an hectare for broadcast and 5 – 10 milliliters per 1 liter for foliar IPT. Surmount is 3.51 – 4.68 liters an hectare for broadcast application and 10 - 20 milliliters per 1 liter for foliar IPT treatment. MezaVue is 1.76 – 2.34 liters an hectare for broadcast and 10 – 20 milliliters per 1 liter for foliar IPT.

Three chemical formulations have been used to control prickly pear: Picloram, Fluroxypyr, and Aminopyralid. Fluroxypyr and Aminopyralid are typically used in mixtures with Picloram to enhance mortality rates. Picloram has been the most effective of the three in the desolation of prickly pear (Mayeux and Johnson 1989). All three chemicals are systemic herbicides derived from the Pyridine chemical formulation. The mode of action is to promote overgrowth in the plant to the point where it causes death. All three active ingredients can be translocated into the plant by the roots or through the pads (Bovey et al. 1972). Different combinations of these active ingredients will apparently result in different lengths of time to totally desiccate the target plant.

METHODS

Research was conducted at three different sites in west-central Texas. One site was located at the Angelo State University Management, Instruction, and Research (MIR) Center. The other two sites were located at the Owens Ranch in Barnhart, Texas. The target site at the MIR Center was located at 31.5071 N, -100.5243 W, which was approximately 13 kilometers North of San Angelo, Texas located off U.S. Highway 87 North. This site was based in a semi-arid environment where the springs and falls are genuinely warm and wet, winters are mild, and summers are hot. Annual precipitation for this site was 53.35 centimeters a year with a growing season of 233 days and mean daily temperatures range from 14° Celsius in January to 35° Celsius in July. The native vegetation in and around the site included Hooded Windmill grass (*Chloris cucullate* Bisch.), Purple Threeawn (*Aristida purpurea* Nutt.), Tobosa (*Pleuraphis mutica* Buckley), KR Bluestem (*Bothriochloa ischaemum* var. songarcia), Silver Bluestem (*Bothriochloa saccharoides* (Sw.) Rydb), Texas Wintergrass (*Nassella leucotricha* (Trin. & Rupr.) Pohl), and Sand Dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray). Honey Mesquite (*Prosopis glandulosa* Torr.) and other deciduous shrubs were also common on the site. The soil for the site was an Angelo clay loam soil type, which are well-drained, moderately slow permeability, and have slow runoff.

The second and third targeted sites (Gene and Lane) were located at 31.0738 N, -101.1729 W and 31.0713 N, -101.1875 W, which were approximately 82 kilometers southwest of San Angelo, Texas off U.S. Highway 67 near Barnhart, Texas. The environmental conditions were very similar to those of the site located North of San Angelo. Most of all the native vegetation is similar to the location on the MIR Center. The two sites at the Barnhart location consisted of a Texon-Ozona and Irion clay mixture. These soils were shallow, gravelly, and cobbly with very low water capacity.

Each of the three sites were divided into 12 plots. Each plot was 10 x 10 m with a 5 m buffer in between. Measurements were recorded two times throughout the trial; a pre-application assessment and one post-application assessment. In each individual plot, canopy cover of prickly pear was measured (cm) diagonal across plots, total number of prickly pear plants were counted, and three forage clipping samples per plot were taken. Each forage sample was taken using a clipping frame $0.33m^2$ quadrant that was randomly placed three times throughout the plot. Samples were then clipped and separated into individual grass species and bagged. Once bagged, each sample was dried (60^0 C for 48 hrs) in a forced-air oven and weighed to record forage kg $\cdot$ ha^{-1}.

Once the initial pre-application measurements was recorded, each plot was assigned a random treatment to spray prickly pear within the plot. Each chemical treatment (Tordon 22K, Surmount, and MezaVue) along with a control were randomly assigned to a plot and replicated three times at each site. This trial used the suggested IPT rate of each of the three chemicals (Tordon 22K, Surmount, MezaVue) to spray prickly pear. After the plots were sprayed measurements were collected one more time (9 months post-treatment) to evaluate prickly pear mortality rates and forage production.

Canopy cover, number of live pads, and forage production were recorded at pre-treatment and 9 months post treatment. This data was used to compare (1) reduction in canopy cover and mortality rate at 9 months post-treatment, and (2) to estimate the expected increase in forage production at 9 months post-treatment. Analysis of herbicide cost effectiveness was observed by comparing each individual herbicide's cost per liter, cost per plant and cost per hectare IPT.

Data was analyzed using repeated measures analysis of variance using a randomized block design with location as the block, treatment as the main effect, and time of collection as the repeated measure. Plots nested within sites served as replications. Means were separated using Tukey's Protected LSD with $P \leq 0.05$. Data was analyzed using the statistical package JMP (SAS Institute 2007).

RESULTS

Spraying prickly pear with MezaVue, Surmount, and Tordon 22K increased the mortality rates compared to no spraying (Fig. 1). However, mortality rates differed by location (Fig. 2), and the Treatment by Location interaction differed ($P < 0.05$) (Fig. 3). At the ASU location, MezaVue had the highest mortality rate with similar mortality rates for Surmount and Tordon 22K. Some prickly pear plants also died in the Control plots at ASU. At Gene location, mortality rates were similar for MezaVue and Surmount. Both MezaVue and Surmount resulted in higher mortality rates than Tordon 22K or Control plots, while Tordon 22K improved mortality over no spraying (Control). At the Lane location, MezaVue, Surmount, and Tordon 22K all resulted in higher mortality rates than no spraying. At this location, mortality rates were similar among the three spraying treatments (Fig. 3).

Initially, canopy cover (cm of prickly pear cover) differed by locations. ASU had the highest initial canopy cover (259.1 cm ± 30.8) followed by Lane (88.5 cm ± 30.8) and the Gene location (52.1 cm ± 30.8). The treatment effect and all interactions with treatment were similar ($P \geq 0.05$). There was a general trend with MezaVue, Surmount, and Tordon 22K reducing canopy cover of prickly pear, but the response was not consistent at each location (Table.1). At the ASU location, MezaVue and Surmount appeared effective in reducing canopy cover of prickly pear while Tordon 22K was not. At the Gene location, both MezaVue and Tordon 22k appeared effective in reducing canopy cover of prickly pear while Surmount was not, while at the Lane location, all three herbicide applications appear effective at reducing prickly pear cover.

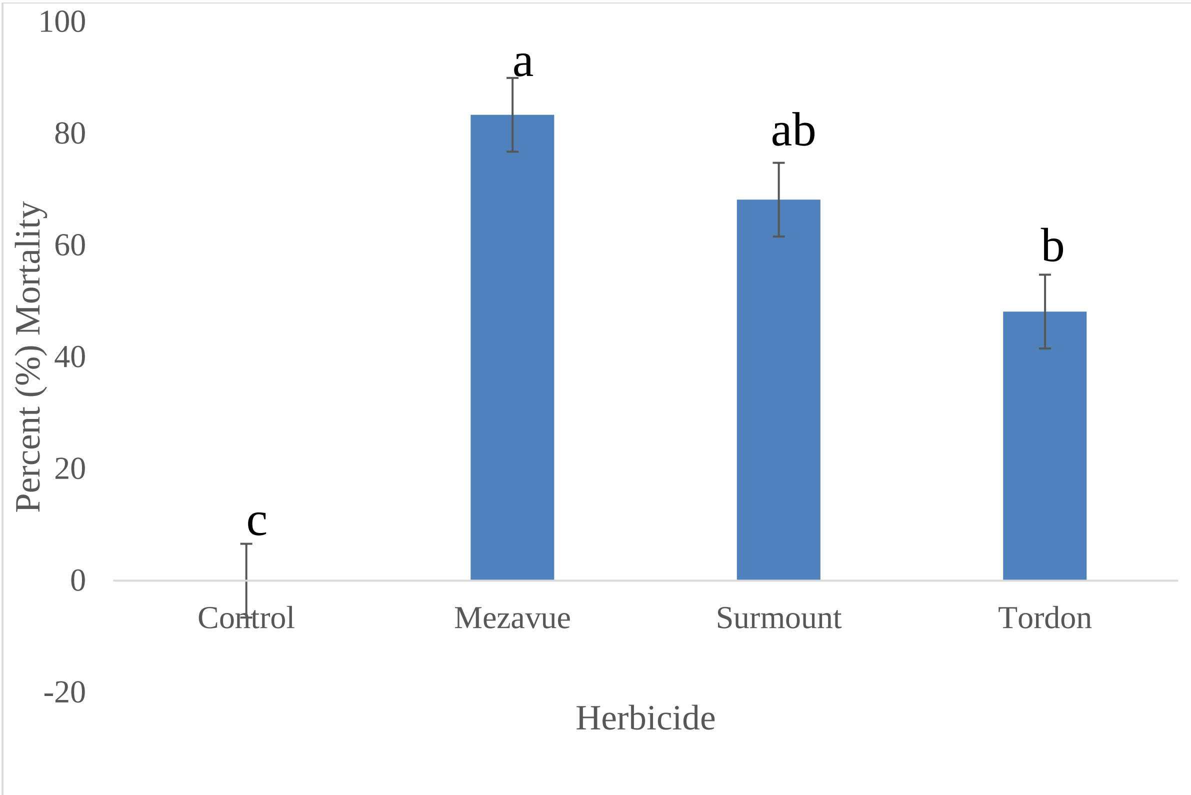

Fig. 1. Percent (%) mortality rates following no treatment (control), MezaVue, Surmount, or Tordon 22K from all three locations. Treatments were applied in February with mortality rates measured in October. Means with different superscripts differ ($P < 0.05$).

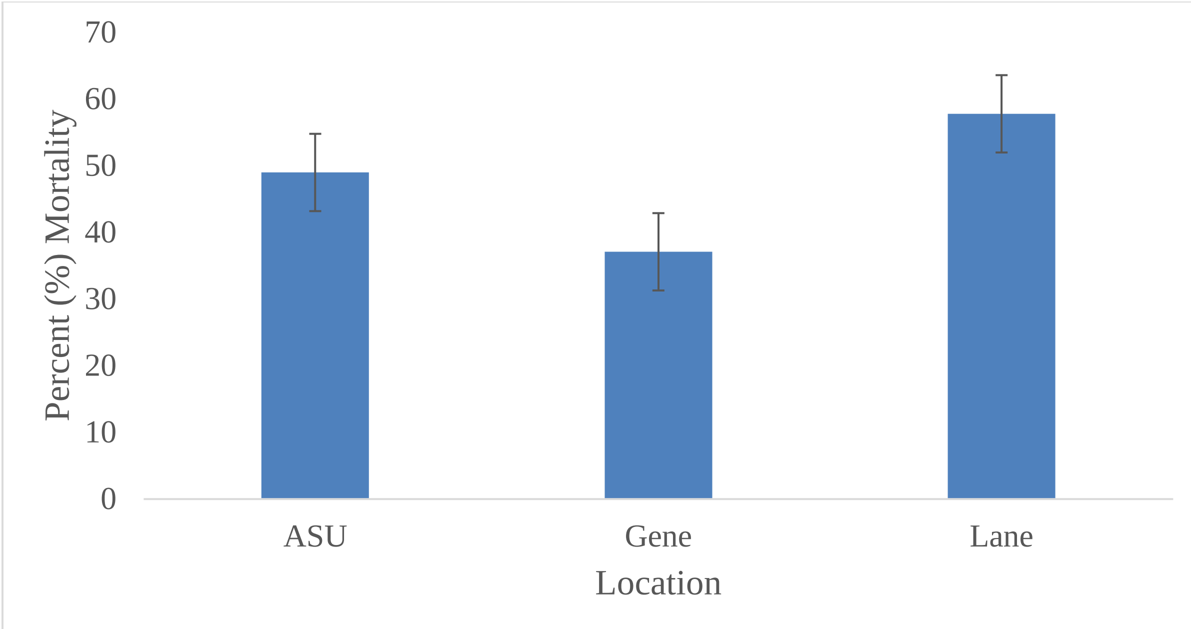

Fig. 2. Percent (%) mortality rates averaged out for each individual site. Averages combined no treatment (control), MezaVue, Surmount, and Tordon 22K mortality percentages.

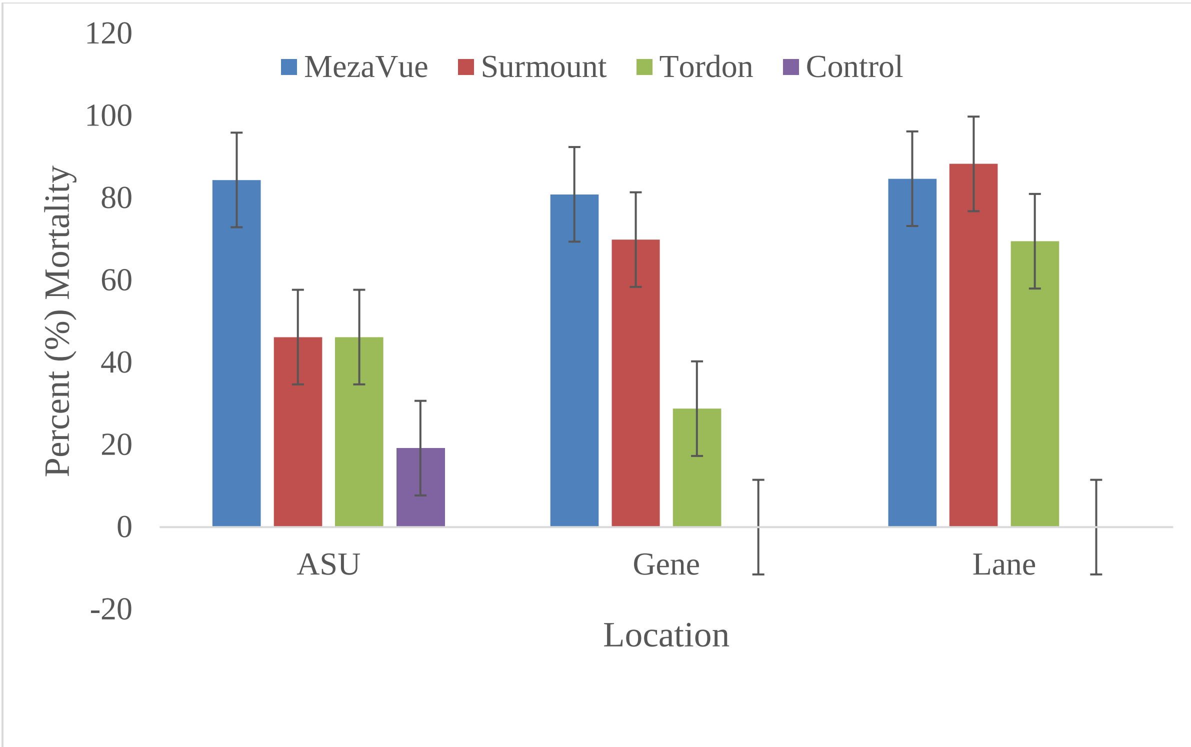

Fig 3. Percent (%) mortality rates following (no treatment) control, MezaVue, Surmount, or Tordon 22K analyzed individually at each treatment site.

Table 1: Canopy cover of prickly pear (cm of prickly pear) pre-spraying (initial) and post-spraying (ending). Plots were sprayed at three locations (ASU, Gene, Lane) with MezaVue, Surmount, or Tordon 22K. Control plots were not sprayed. The treatment by location by time interaction did not differ (*P* = 0.30).

	Canopy Cover		
Location/Treatment	**Initial**	**Ending**	**SEM**
ASU			
MezaVue	345.3	5.0	61.6
Surmount	121.3	51.7	
Tordon	199.0	121.7	
Control	370.7	240.0	
Gene			
MezaVue	56.7	0	61.6
Surmount	33.0	31.7	
Tordon	86.7	6.7	
Control	31.7	28.3	
Lane			
MezaVue	16.7	0	61.6
Surmount	103.3	8.3	
Tordon	126.0	27.0	
Control	108.3	82.7	

Initial forage production (kg · ha^{-1}) differed among the three locations. Prior to any herbicide treatments, forage production was initially highest at ASU (1,014.2 kg ± 145.1), followed by Lane (981.7 kg ± 145.1) and Gene (350 kg ± 145.1). Spraying prickly pear (treatment effect) and all treatment interactions were similar for forage production following treatment applications ($P > 0.05$) (Table. 2).

The cost effectiveness of each individual herbicide was analyzed by breaking down how much each herbicide would cost to spray an average size prickly pear and by hectare. (Table. 3) MezaVue and Surmount cost the same while treatment with Tordon 22K cost less. MezaVue uses the third active ingredient (Aminopyralid) in its formulation thereby reducing the rate of application for 2% (Surmount) to 1% with MezaVue. At the ASU location, MezaVue appears to be effective and potentially the most cost effective given the higher mortality rate and greater canopy cover reduction. However, forage production did not increase accordingly. At the Gene location, mortality rates were similar for MezaVue and Surmount while canopy cover of prickly pear appeared lower following MezaVue treatment. Although not significant forage production appears higher at the Gene location regardless of herbicide treatment.

Tordon 22K is the least expensive herbicide application for prickly pear. At the Lane location, mortality rates were similar among all three herbicides indicating that Tordon 22 K was the most cost-effective treatment for prickly pear control.

Table 2: Forage production (kg · ha^{-1}) pre-spraying (initial) and post-spraying (ending). Plots were sprayed at three locations (ASU, Gene, Lane) with MezaVue, Surmount, or Tordon. Control plots were not sprayed. The treatment by location by time interaction did not differ (P = 0.67).

	Forage Production		
Location/Treatment	**Initial**	**Ending**	**SEM**
ASU			
MezaVue	836.7	489.0	290.2
Surmount	1,196.7	523.0	
Tordon	753.3	739.3	
Control	1,270.0	1,173.7	
Gene			
MezaVue	436.7	889.0	290.2
Surmount	130.0	638.3	
Tordon	440.0	1,038.0	
Control	393.3	889.0	
Lane			
MezaVue	906.7	955.0	290.2
Surmount	1,013.3	1,282.0	
Tordon	683.3	1,131.3	
Control	1,323.3	926.3	

Table 3: Cost effectiveness of each individual herbicide based on a per/liter, per/plant, and per/hectare individual plant treatment.

	Herbicide Cost Effectiveness		
	MezaVue 1%	**Surmount 2%**	**Tordon 22K 1%**
Cost			
$/Liter	$31.70	$15.69	$20.87
$/Plant	$0.24	$0.24	$0.16
$/Hectare IPT	$240.92	$240.92	$158.00

DISCUSSION

All three herbicides resulted in prickly pear mortality but had limited impact on prickly pear canopy cover and forage production at 9 months post-treatment. Mortality rates, canopy cover and forage production will be assessed again at 12, 24, and 36 months post-treatment. Unfortunately, this data was not available for this thesis. MezaVue apparently controls prickly pear at a faster rate than other herbicide mixtures. Unfortunately, the results of this study do not support this claim at 9 months post-treatment. Field observations have noted that Tordon 22K often takes 36 months for complete plant mortality. Thus, mortality rates may change over time. Determining the rate of return on investments in herbicide control of invasive plants relies on the lifetime of improvements. Those treatments that typically control invasive plants for longer periods of time are typically more cost effective. Continued monitoring of the plots will be used to determine the potential lifetime of control following treatment with Tordon 22K, Surmount, and MezaVue.

Rainfall may have impacted the results of this study. Seasonal changes such as above or below average rainfall can have an affect on photosynthetic herbicides and the rate at which the herbicides are absorbed, translocated, and the direction they travel (Potter et al. 1986). Precipitation differed between the two locations (Fig. 4). In addition, soil type and initial cover of prickly pear and grass production may have confounded the results of this study. The site at ASU was sprayed in November of 2018. During November, it rained 0.56 cm. and the following month of December it rained 6.76 cm. This site received below average rainfall directly following the application of the herbicides but then received average precipitation a month later. Soil moisture affects the uptake and translocation of the

Picloram, one of the active ingredients in MezaVue and Surmount and the primary active ingredient in Tordon 22K.

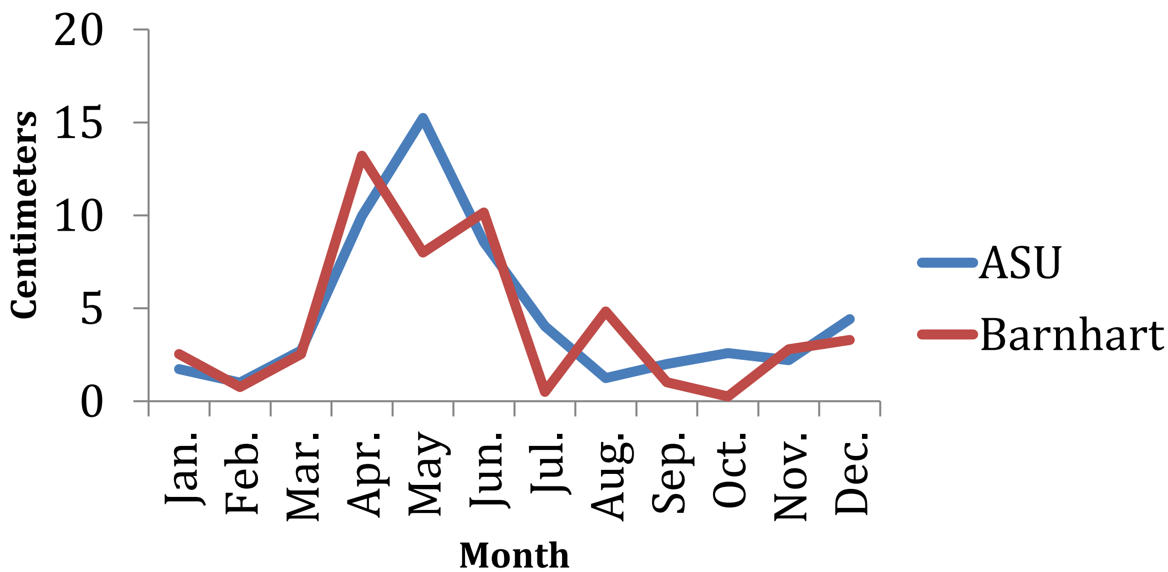

Fig 4. Average monthly rainfall for ASU and Barnhart (Gene and Lane sites combined) locations.

When soil moisture is average, control of prickly pear is typically higher. The next three months received below average rainfall which may have affected the herbicides being absorbed into the targeted species and translocated to the growing points of the plant. The other two sites, Gene and Lane, were sprayed in February and followed a very similar weather pattern throughout the length of the trial except in the middle three months, where ASU received average rainfall these two sites did not. Those three months showed less rainfall. All three sites had a period of average precipitation but it was all received before the growing season. Once the growing season began in May little to no precipitation fell. The lack of rainfall may not have allowed the herbicide to translocate and break down the canopy cover which in return affected vegetation response at all three sites.

Increases in forage production should have occurred following treatment of prickly pear, especially in plots with higher mortality rates. Unfortunately, that observation was not noted in this study. At the ASU location, forage production tended to be lower following all treatments, including the control. At the Lane location, forage production was similar pre- and post-application. While at the Gene Location, forage production tended to be higher regardless of treatment. While reasons for this response remain unclear, it appears that below average rainfall following treatment may have impacted the results of this study. In addition, rainfall may have interacted with initial canopy cover of prickly pear or soil type to confound any effect of controlling prickly pear with herbicides in this study.

MANAGEMENT IMPLICATIONS

The main focus of this study was mortality rates and forage production immediately after spraying the three different herbicides on prickly pear. Apparently, MezaVue results in a faster mortality rate of prickly pear thereby resulting in a rapid initial increase in forage production. The results of this study do not support that claim. At this point, it appears that treatment with MezaVue, Surmount or Tordon 22K will effectively control prickly pear and may improve forage production within 9 months of treatment. However, response rates may vary by location and soil type. Producers should effectively control prickly pear when needed to enhance forage production.

This study only evaluated prickly pear and forage response following IPT. Future efforts should evaluate the same variables following broadcast treatment with the same herbicides. Differences in application rates and cost may justify the use of one herbicide application over the other. In addition, results may differ on different locations with differences in initial canopy cover of prickly pear, initial forage production, or precipitation regimes. Both IPT and broadcast treatments should be applied at different locations with variations in growing conditions.

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VITA

My name is Stewart Gregory Hohensee. I grew up in Miles, Texas learning land conservation and the value of a hard day’s work. My mentors have taught me that dedication and hard work will allow me to accomplish any goal. I completed my Bachelor’s degree from Angelo State University in San Angelo, Texas in May of 2018. My degree was in Agribusiness with a minor in Range and Wildlife Management. Currently, I am completing my Master’s of Science degree in Animal Science with a focus in Range and Wildlife Management at Angelo state University and am projected to graduate in May of 2020. Currently, I am employed at Texas A&M Agrilife Research & Extension Center in San Angelo, Texas. My supervisors are Dr. Morgan Treadwell of the department of Rangeland, Wildlife, and Fisheries management at Texas A&M Agrilife Extension District 7. Dr. Reagan Noland of the department of Soil and Crop Sciences at Texas A&M Agrilife Extension District 7. Dr. John Walker of the department of Ecosystem Science and Management at Texas A&M Agrilife Research District 7. My duties include but are not limited to assisting in managing temporary staff, data collection, record keeping, maintenance of field and laboratory equipment, record keeping of all required licenses for restricted chemical and fertilizer applications, and conducting instructive presentations at yearly county workshops and CEU trainings.